

A NEW GENUS OF OPERCULATE LAND SNAILS
FROM HISPANIOLA WITH COMMENTS ON
THE STATUS OF FAMILY ANNULARIIDAE

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Hispaniola is inhabited by many exquisite land animals. It has an especially rich and diverse gastropod fauna. Although much has been written about Hispaniolan mollusks, large geographic areas remain virtually unexplored for land snails and many new forms remain to be described. During the past two years I spent about eight months in the field in the Dominican Republic and made extensive collections of land snails from most areas of the country.

The physiography of Hispaniola is complex. It consists of many mountain ranges, ridges, and isolated hills, all of which combine to form a mosaic of faunal regions. The Cordillera Central consists mostly of igneous and metamorphic rocks, and calciphyllic families of land snails, such as the Urocoptidae and Annulariidae, are conspicuously absent. Elsewhere, to the north, east, and south, calcareous substrates predominate. In these areas some hills and mountain ranges have a high degree of molluscan endemism. One such mountain ridge in Puerto Plata Province is inhabited by a most unusual land snail, whose transparent shell with high fragile ribs cause it to resemble a giant snowflake. It is one of the most striking terrestrial operculates to have been discovered. The transparent, high ribs of the shell is an adaptation for a cryptic existence on an exposed limestone surface. The snail is highly unnoticeable because of the blurred image that is created by its sculpture. This delicate, ornate sculpture is unrivaled by any other known species of "cyclostomid," although similar ornamentation occurs in some members of the pupinid genus *Geothauma* from Borneo.

The snail described herein is a member of the family Annulariidae and the subfamily Annulariinae as defined by Henderson and Bartsch

(1920). Controversy exists over the availability of the generic name *Annularia* Schumacher, 1817 as opposed to *Choanopoma* Pfeiffer, 1848 and Annulariidae as opposed to Chondropomidae or Pomatiasidae (see Henderson and Bartsch, 1920; Baker, 1924a: 2-3, Solem, 1960: 419-420; 1961: 192-194). This case is currently before the international Commission on Zoological Nomenclature. For purposes of this paper I tentatively accept Dall's (1905: 298) type species designation of *Turbo lincina* Linnaeus for *Annularia*. Annulariidae Henderson and Bartsch (1920: 54) has page priority over Chondropomi-(dae) Henderson and Bartsch (1920: 59). I arbitrarily follow the subfamily division proposed by Henderson and Bartsch (1920) and Baker (1924a). Later authors, who criticized Henderson and Bartsch's classification, did not provide more useful alternatives. For reasons given below I consider the neotropical Annulariidae and the Old World Pomatiasidae to be separate families.

Licinae Pfeiffer, 1858 was the first family-group taxon name used for the neotropical "cyclostomes." Except for occasional use in the mid-nineteenth century the name went unmentioned in the primary literature until Golikov and Starabogatov (1975) resurrected it as the family name Licinidae. The name Licinidae Pfeiffer is a *nomen oblitum* because of this great time lapse and thus is not available for use (ICZN Article 23, b).

Field work relating to this study was supported by the National Geographic Society, Council for Research, and the Florida State Museum. I am grateful to officials of both organizations for the support they have given me. Dr. Joseph Rosewater (USNM) and Dr. Charlotte Patterson (UMMZ) kindly loaned to me dried specimens of *Cistulops* and *Troschelvindex* from which radulae were extracted

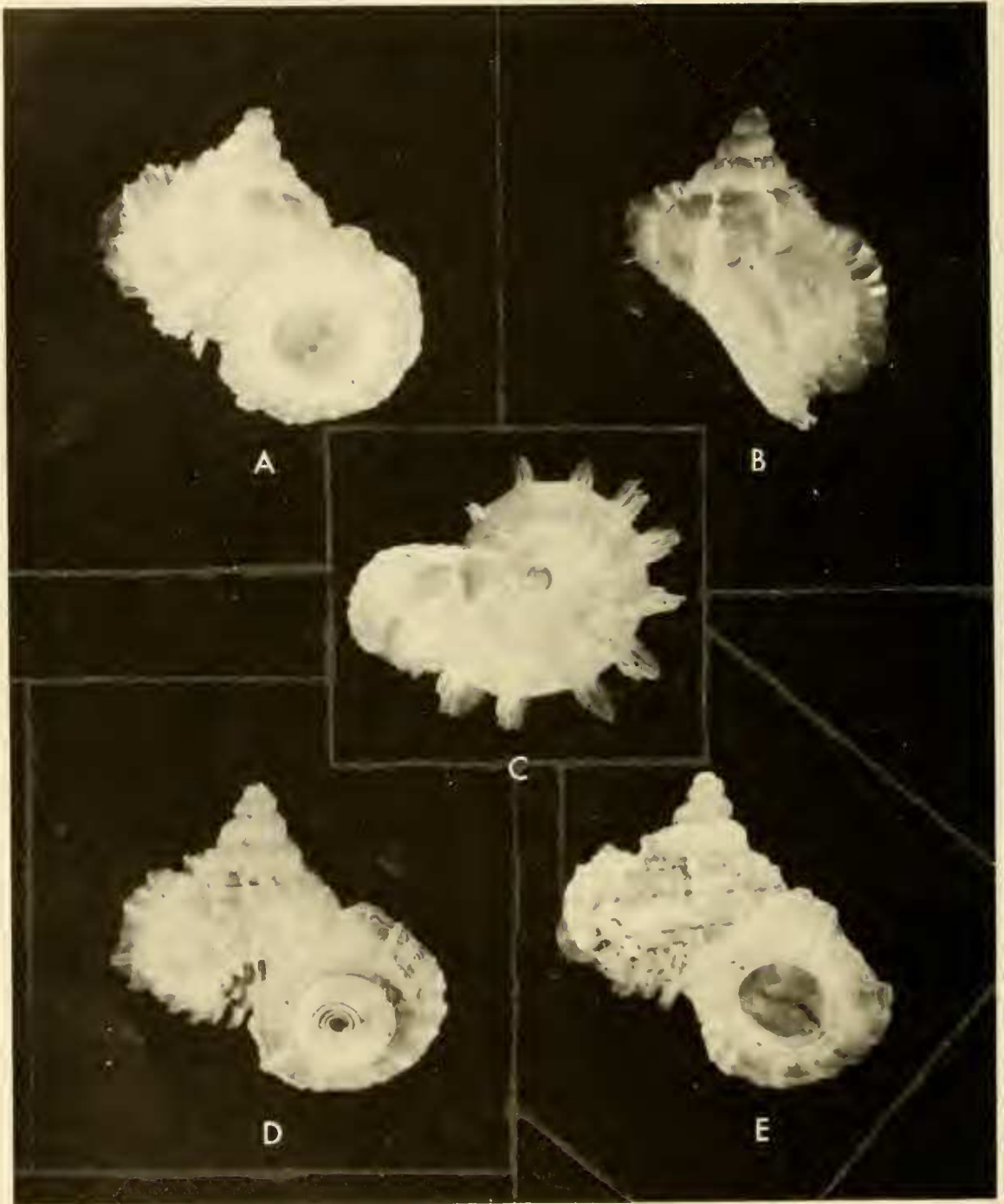


FIG. 1. *Meganipha rheeta*, new genus and new species, Thompson. A-C. Holotype (UF 22745). D. Paratype (UF 22747). E. Paratype (UF 22746).

for SEM studies. Preserved specimens of *Pomatias elegans* (Müller) used in this study were collected by Dr. S. David Webb (Florida State Museum) while he was a Gugenheim Scholar in France during 1973. I am grateful to the following people who assisted me in field work in the Dominican Republic: Howard W. Campbell, Ronald Crombie, Richard Franz, Roy McDiarmid, Sylvia Scudder, Linda Wiley, and especially Beverly E. Johnson whose energy for hiking up mountains and searching for snails seemed nearly inexhaustible. The photographs comprising fig. 1 were made by Donna B. Drake; SEM micrographs were made by Sylvia Scudder.

Meganipha new genus

Type species: *Meganipha rhecta* new species.¹

This is a genus of the Family Annulariidae, subfamily Annulariinae. The shell is helicoid with raised nipplelike apical whorls. Spiral sculpture is obsolete. It is indicated only by the undulating bases of the ribs, which occur in spiral sequences. Otherwise the shell is devoid of spiral sculpture even in the umbilicus. The axial sculpture consists of extremely high, widely-spaced fragile ribs that are about half the diameter of the whorl in height. The peristome is double. The outer peristome is very broadly expanded, slightly more so than the ribs, and is recurved posteriorly along its outer edge. The face of the outer peristome is sculptured with numerous close spiral striations.

The operculum bears a raised spiral calcareous lamella that is reflected laterally so that it overlaps, but does not fuse with succeeding turns. The lamella lacks reinforcing ribs or buttresses. The outermost turn of the lamella is reflected beyond the basal chandroid plate so that the operculum is too large to be retracted into the aperture.

The relationship of *Meganipha* to the Annulariinae is clearly indicated by its operculum. In this subfamily it bears a raised spiral calcareous lamella which may be reflected to parallel the basal plate. The lamella may lack reinforcing ribs so that an open cavity is formed between the reflected

lamella and the basal plate, or reinforcing ribs may be present, which partially obstruct the cavity.

Meganipha belongs to an assemblage of closely related Hispaniolan genera that includes *Petasipoma*, Bartsch, 1946, *Rolleia*, Crosse, 1891, *Lagopoma*, Bartsch, 1946, and *Abbottella*, Henderson and Bartsch, 1920. This group contains helicoid, depressed-helicoid, or discoidal species that have a double peristome. The genera are separated by sculpture, shell shape, and the development of the opercular lamella. It is beyond the scope of this paper to review the status of these genera. However, each is composed of species that represent natural assemblages, and the use of generic names for these assemblages is warranted. *Petasipoma* has a helicoid shell with both axial and spiral threads. The operculum is unusual in that the lamella is reflected to parallel to the basal plate with successive turns fusing to form a continuous outer plate. The other genera have a gap between the successive turns of the lamella. *Rolleia* is depressed-helicoid and is characterized by having axial ribs only. Spiral sculpture is absent. *Lagopoma* and *Abbottella* have spiral sculpture as well as axial ribs. *Lagopoma* differs from *Abbottella* as well as all other Annulariinae by having a notch in the outer peristome over the parietal wall. *Meganipha* differs from these four genera as well as other annulariids and pomatiasids by its sculpture and its outer peristome. No other genus has axial ribs that approach the fragile lamellar condition characteristic of *Meganipha*, and no other described genus has a peristome that is as broadly expanded and bears the characteristic lacey concentric sculpture on its face. The obsolete spiral sculpture on the shell is also characteristic. The operculum is unusual but not unique within the Annulariidae in that it is too large to be withdrawn into the aperture. In the related genera mentioned above the operculum is retractable internally.

Meganipha rhecta new species

SHELL (fig. 1). - This is an elegant, medium-sized snail that is fragile and delicate in structure. The shell is turbiniform in shape with a slightly concave spire. Usually the shell is wider than high, being about 0.90–1.02 times as high as wide. The last whorl flares laterally conspicuously beyond the

¹ ETYMOLOGY. *Meganipha* (f.): from the Greek *megas*, giant, and *nipha*, a snowflake; *rhecta*: from the Greek *rhectos*, brittle. The name *Meganipha rhecta* Thompson appears as a nude name in the *Florida State Museum Newsletter*, June 1976, vol. 5, p. 8 (fig.).

curvature of the spire and has a widely reflected fragile peristome. The thin shell is transparent when alive and clearly shows the viscera internally. The color of the shell is a soft frosty white on a translucent background. Occasional specimens have five reddish-brown spiral bands, three on the base, one on the periphery, and one on the shoulder of the whorls (fig. 1, E). The umbilical perforation is broad, being slightly less than the width of the last whorl. There are about 5.0-5.6 whorls with 2.2-2.3 smooth, raised, nipple-shaped embryonic whorls. The suture is deeply impressed. The first and second postembryonic whorls are weakly angular at the shoulder. The body whorl is only weakly in contact with the preceding whorl and is solute and descends near its termination, leaving a triangular gap behind the peristome. The postembryonic whorls are sculptured with elegant, very thin, very fragile evenly spaced vertical ribs that are about half as high as the diameter of the whorl. There are about 10-12 ribs on the last whorl. The ribs are strongly undulated at their base but are flattened near their outer edge. The interspaces are sculptured with vertical rounded threads and striations that parallel the basal undulations of the ribs. The ribs on the earlier postembryonic whorls are usually broken away, leaving only jagged remnants of their bases. The aperture is slightly higher than wide, and is oblique, lying at an angle of about 35° to the axis of the shell. The inner peristome projects forward only slightly. The outer peristome is very broadly reflected and recurved and is about half as wide as the diameter of the aperture. It is thin and fragile and is sculptured on its face with numerous close raised spiral undulating threads that give the peristome a lacey appearance. The threads are densely crowded near the aperture and are more widely spaced toward the periphery.

The operculum (fig. 1, D) bears a strongly reflected calcareous lamella which contacts itself on each succeeding turn so that a calcareous pseudolamellae is formed on the outer surface leaving a tubular spiral space beneath it. The pseudolamellae lacks reinforcing ribs. Usually the lamella on the inner most 3-4 whorls is broken away, exposing the basal chondroid plate. The operculum does not withdraw into the aperture, but lays nearly flush with the peristome.

Measurements of the holotype and four paratypes selected to show ranges of variation (measurements in parentheses include only the caliber of the whorls and not the ribs or outer peristome).

Radula. - The radula is taenioglossate and extends posteriorly into the coelom for about 0.5 whorls behind the buccal mass. Basically it is similar to the radulae of other annulariids in that the central and lateral teeth are unicuspid. The transverse rows of teeth are close-set so that the teeth broadly overlap at their bases, thus reinforcing each subsequent row in its cutting action when feeding (see Solem, 1974, for similar observations on pulmonates). The central tooth has a long lanceolate cusp that projects at about 90° to the base of the tooth. The basal plate is long and relatively slender and bears a strong reinforcing fold along each side between which the distal half of the preceding tooth lies. The lateral teeth are similar to the centrals, but are broader and the cusp is slightly longer (fig. 2, A, D-1). The inner marginal has a single large triangular mesocone that is rather jagged along its outer edge and bears a small ectocone at its base (fig. 2, B-im). The outside margin of the shaft has a short triangular flange below the cusp so that the two marginal teeth interlock at their bases and along their shafts when in use (fig. 2, B). The outer marginal is broadly triangular in outline due to a thin membrane that extends from the shaft of the tooth to the outer end of the cusp margin (fig. 2, B, C-om). The outer marginal bears about 50 slender, sharp, sickle-shaped cusps along the cutting edge. The cusps are largest near the shaft and gradually decrease in size toward the outer edge.

Reproductive system - The male reproductive system is closed throughout its length and terminates in a long slender penis that is triangular in cross-section (fig. 3, E). The penis originates on the right side of the nape deep within the pallial cavity, and in a resting position it is recurved over the center of the nape so that it is U-shaped with its tip pointed anteriorly. The vas deferens is very short and runs transversely along the body wall from the base of the penis to the prostate. The prostate is imbedded in the right wall of the mantle cavity and lies completely anterior to the transverse wall of

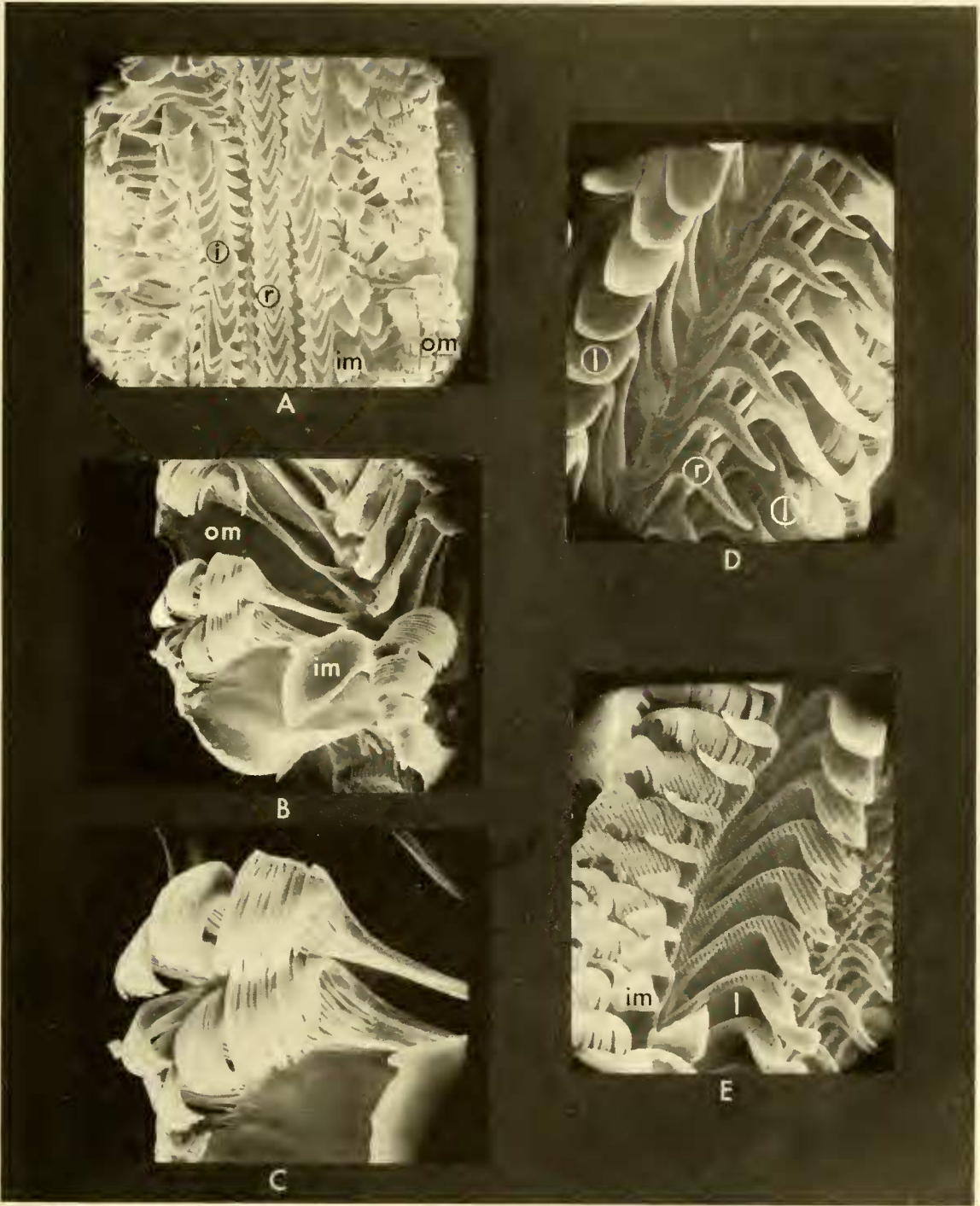


FIG. 2. *Meganipha rhexta*, new genus and new species, Thompson. SEM micrographs of radula (UF 22748). A. Complete transverse section ($\times 105$). B. Marginal teeth ($\times 260$). C. Sickle-shaped cusps of outer marginal teeth ($\times 540$). D. Oblique view of central and lateral tooth rows ($\times 250$). E. Lateral and marginal tooth rows ($\times 245$). Legend: r-central, l-lateral, im-inner marginal, om-outer marginal.

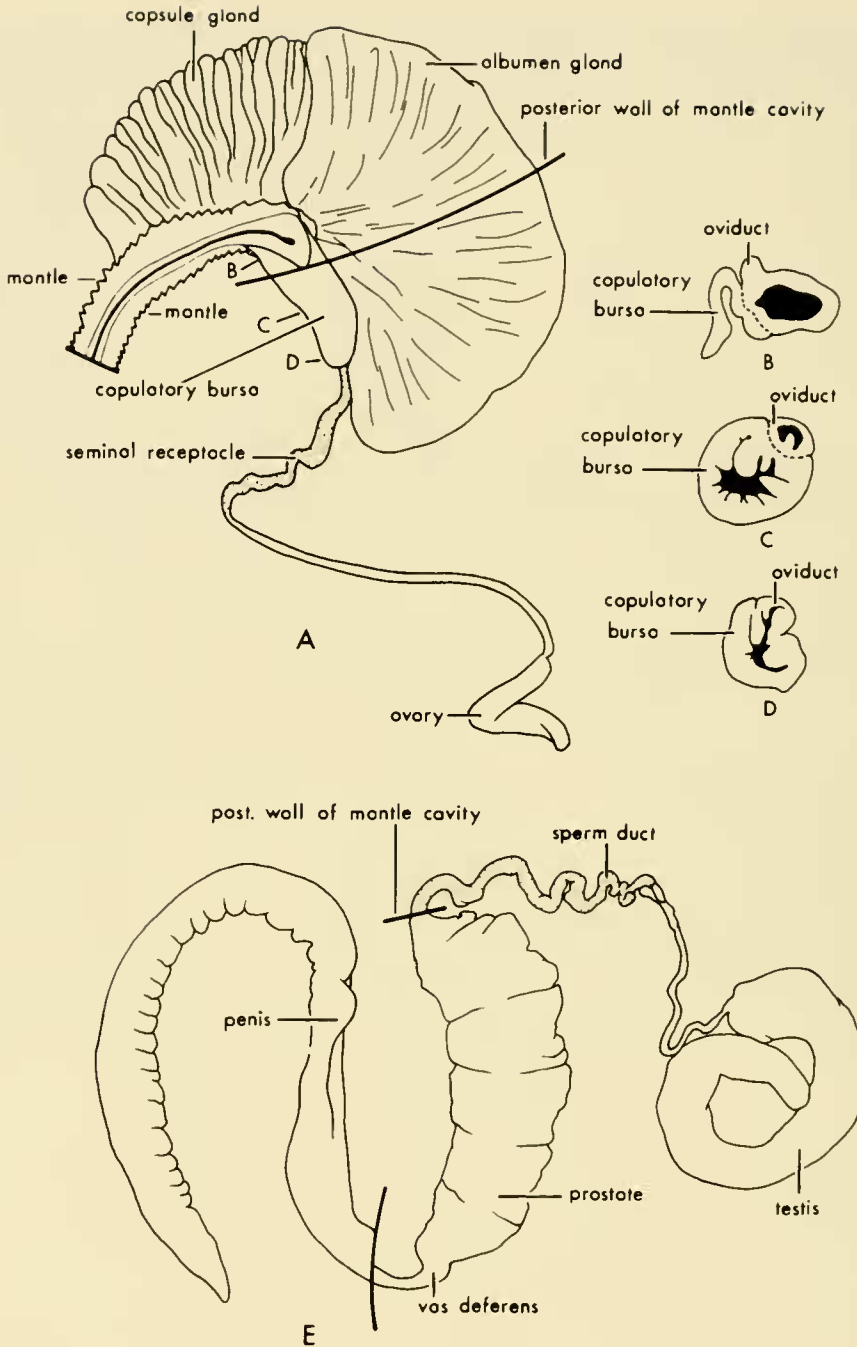


FIG. 3. *Meganipha rhexta*, new genus and new species. A. Female reproductive system. B-D. Transverse sections through copulatory bursa at corresponding points on A. E. Male reproductive system.

the mantle cavity. The testis is fusiform, relatively stocky, is 1.5 whorls long and lies along the columellar side of the digestive gland. The sperm duct is very narrow and thin walled immediately below the testis. It becomes enlarged along its lower half, forming a seminal vesicle that is rather densely pigmented with melanophores. Numerous small yellow concentration granules of uric acid are scattered throughout the visceral cavity and surround all of the visceral and reproductive organs.

The female reproductive system is tripartite, consisting of an ovary, the primary oviduct and its derivatives, and the pallial oviduct (fig. 3, A). The ovary is elongate-cylindrical and occupies about 1.5 whorls along the basocolumellar side of the digestive gland. The primary oviduct originates from the anterior end of the ovary. It is thin-walled and expands along its lower third to form a densely pigmented seminal receptacle. The oviduct continues in the basal wall of the copulatory bursa

(fig. 3, B-D) to the albumen duct, and from there into the capsule gland. The copulatory bursa is thick walled and has about 10-12 longitudinal folds protruding into its lumen. An enlarged fold along the columellar side partially divides the lumen longitudinally. The lumen continues into the seminal receptacle by a very narrow perforation at the posterior end of the bursa. The albumen gland is strongly compressed laterally. It overlaps the posterior wall of the mantle cavity so that its posterior half lies along the columellar side of the visceral mass and its anterior half borders the mantle cavity. The capsule gland is a voluminous multifolded chamber that is open throughout its length along the columellar angle of the mantle cavity and beneath the intestine. It contains about 20 vertical undulating folds which presumably expand into a large chamber during ovulation, as occurs in *Pomatias* (see Creek, 1951: 608-609).

Nervous system (fig. 4, A, B). - The brain is an advanced epiathroid type in which the pleural

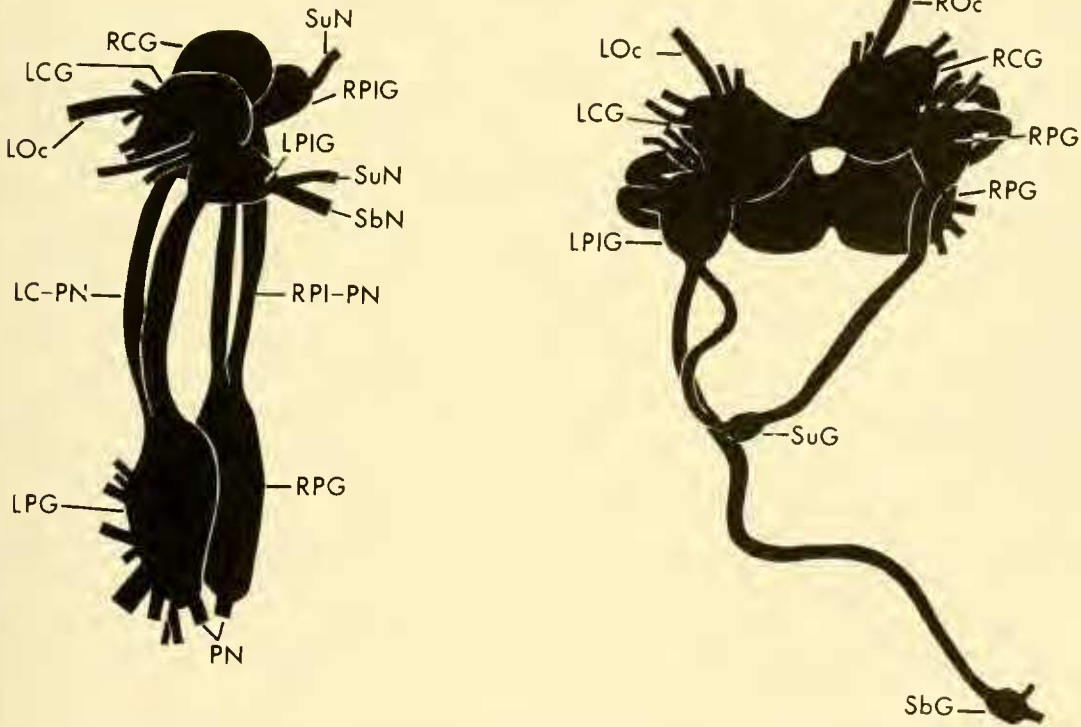


FIG. 4. *Meganipha rhecta*, new genus and new species. Central nervous system. A. Lateral view. B. Dorsal view. Legend. LCG-left cerebral ganglion, LC-PN-left cerebral-pedal nerve; LO-left ocular nerve; LPG-left pedal ganglion; LPIG-left pleural ganglion; PN-pedal nerves; RCG-right cerebral ganglion; RPG-right pedal ganglion; RPIG-right pleural ganglion; RPI-PN-right pleural-pedal nerve; SbG-suboesophageal ganglion; SbN-suboesophageal nerve; SuG-supraoesophageal ganglion; SuN-supraoesophageal nerve.

ganglia are moved dorsally and are fused with the posterior-lateral corner of the cerebral ganglia. The nerve ring encircles the center of the buccal mass midway between the mouth and the esophagus. The cerebral-pedal connective are independent throughout their lengths. The pedal ganglia are retained within the haemocoel of the foot, a single commissure connects the two pedal nerves. The cerebral ganglia are joined by a short, broad commissure, and each gives rise anteriorly to two labial nerves, the optic nerve and two buccal nerves. Zygoneury occurs between the left pleural ganglion and the supraoesophageal ganglion which lies against the body wall to the left of the esophagus. The connectives between both pleurals and the supraoesophageal ganglia are relatively long for an advanced epiathroid condition. The suboesophageal ganglion lies along the right side of the body wall just below the base of the penis. Zygoneury with the right pleural ganglion does not occur. The penis is innervated by the suboesophageal ganglion, and thus it is pallial in origin and not pedal as in *Pomatias* (Creek, 1951).

Type locality - Dominican Republic, Puerto Plata Province, Loma del Puerto, Yaroa, 700 m elevation. Holotype: UF 22745; collected 11 January, 1976 by Fred G. Thompson and Beverly E. Johnson. Paratypes: UF 22746 (21), UF 22747 (114), USNM 711132 (6); same locality as the holotype.

The type locality is in a mountain fog forest where the prevailing northeasterly winds pass over the crest of the mountain. The crest consists of a rugged karsted limestone outcrop that is shrouded by a dense forest of trees, shrubs, and ferns. A thick carpet of moss covers practically all trees and substrate. Snails were found crawling and aestivating on bare overhanging limestone surfaces. The shells appeared as grayish blurs against the gray calcareous background.

SYSTEMATIC STATUS OF THE ANNULARIIDAE

The status of the neotropical Annulariidae has been a matter of controversy since the group was first separated from the Old World Pomatiasidae (Pfeiffer, 1858 [Licinae]; Dall, 1905; Henderson

and Bartsch, 1920; Baker, 1924a, 1924b; Thiele, 1931; Torre and Bartsch, 1928, 1941; Bartsch, 1946; Wenz, 1938; Solem, 1960, 1961; Golikov and Starabogatov, 1975 [Licinidae]. The criterion used by Henderson and Bartsch (1920) to separate the Annulariidae from the Pomatiasidae is the structure of the central tooth of the radula. Arguments against the recognition of two distinct families has to do with the cusp variations that occur in some neotropical species of the subfamily Cistulopsinae.

While determining the phyletic relationships of *Meganipha* it is necessary to reconsider the systematic status of the Annulariidae. Four anatomical systems possess significant characteristics relevant to this problem: (1) the radula, (2) the male reproductive system, (3) the female reproductive system, and (4) the nervous system. Anatomical information on these two families is very limited. Creek (1951) described the reproductive systems of *Pomatias elegans* (Müller). Fretter and Graham (1962: 310) described the nervous system of *P. elegans*. Venmans (1959) described the radula of *P. sulcatus* (Drap.) and *P. militensis*. Other than various accounts of the radula, the soft anatomy of no neotropical species has been described previous to this report. However limited it may be, the data currently available suggests that the annulariids and the pomatiasids are separable as distinct families.

RADULA

Henderson and Bartsch (1920) separated the neotropical Annulariidae from the Old World Pomatiasidae on the basis of the central tooth of the radula. The neotropical species have a narrow unicuspid central tooth in contrast to the broad tricuspid central tooth of the Pomatiasidae. The observations by Henderson and Bartsch were slightly in error. The central tooth of the Pomatiasidae has five cusps, not three, and not all annulariids are unicuspid.

Baker (1924a: 1-4) showed the two neotropical species, *Cistulops raveni* (Cross) and *Troschelvindeix illustre* (Poey) [= *T. candeana* (Orbigny)], have a tricuspid central tooth which bears a long slender mesocone and a minute ecotocone on each side. He proposed the subfamily Cistulopsinae for these genera and suggested that they are primitive in

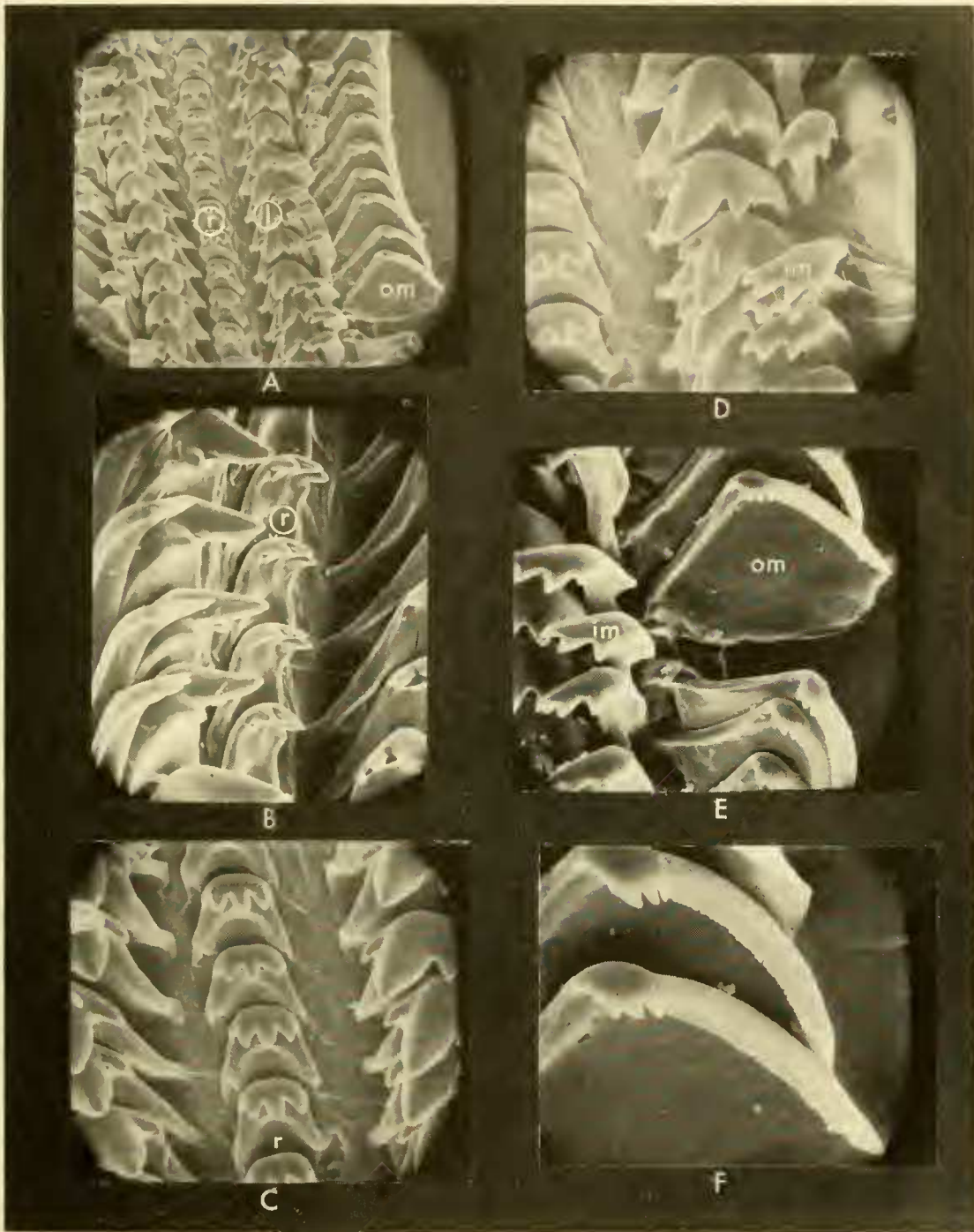


FIG. 5. *Pomatias elegans* (Müller); SEM micrographs of radula; Montpellier, Dept. L'Herault, France (UF 22749). A. Nearly complete transvers section ($\times 110$). B. Oblique view of central row (r) ($\times 260$). C. Vertical view of central row ($\times 240$). D. Vertical view of lateral and inner marginal rows ($\times 260$). E. Inner marginal and outer marginal teeth ($\times 270$). F. Cusps on outer marginal teeth ($\times 520$). Legend: r-central, l-lateral, im-inner marginal, om-outer marginal.

characters of the radula and operculum and are intermediate between the Pomatiasidae and the Annulariidae.

Later authors (Baker, 1924b, 1928; Solem, 1960, 1961; Thompson, 1966) continued to place the neotropical species in the Pomatiasidae because of the intermediate phyletic position that Baker suggested for the Cistulopsinae. SEM examination of the radulae of the genera in question reveals the presence of several characteristics that distinguish the neotropical Annulariidae, including the Cistulopsinae, from the Old World Pomatiasidae. Brief descriptions are given of the radula of relevant genera.

POMATIASIDAE. *Pomatias elegans* (Müller) (fig. 5). Five radulae were removed from the preserved specimens (UF 22749; Montpellier, Dept. L'Herault; France). The transverse rows of teeth overlap only slightly and give weak support to subsequent rows when in use. The central tooth is very broad and has five cusps on the cutting edge. The three foremost cusps are nearly equal sized and are flanked posteriorly by a small tubercular ectocone (fig. 5, B, C-r). The lateral tooth is broadly trapezoidal in shape and bears four heavy cusps: a small entocone, a large lanceolate mesocone, and two ectocones (fig. 5, D-1). The inner marginal has a narrow shaft and base and bears five subequal-sized cusps (fig. 5, D, E-im). The outer marginal is broadly triangular in shape with a wide membrane extending from the base of the shaft to the outer extremity of the rasping margin (fig. 5, E, F-om). The mesad end of the rasping margin overlying the end of the shaft bears three relatively strong, nearly equal sized cusps which are flanked laterally by about 42 small slender blunt filiform cusps. *Pomatias sulcatus* (Drap.) and *P. militensis* (Sow.) differ from *P. elegans* only in the number of cusps on the lateral teeth, not in qualitative differences (see Venmans, 1959).

Tropidophora haemastomum (Anton). Two radulae were extracted from dried specimens (UF 23558; Round Island, Indian Ocean). In most essential features the teeth are like those of *Pomatias elegans*, except that the outer marginal tooth has six enlarged cusps over the end of the shaft (fig. 6, D).

ANNULARIIDAE. The radula of *Meganipha rhecta* n. sp. is described earlier in this paper (fig. 2). Baker (1924a, 1928) examined the radula of about 60 neotropical species. He noted (1924a: 2, 1928: 47-49) the nearly uniform radular structure throughout this group and pointed out two minor variations, one upon which he based the subfamily Cistulopsinae Baker, 1924 (see above) and the other he used (1928: 48) as a basis for a new subgenus of *Licina*, (*Choanopomops*). All of the Annulariidae for which the radula has been described, have in common: (1) strongly overlapping transverse rows of teeth in contrast to the less overlapping rows in the Pomatiasidae; (2) a narrow unicuspid or weakly tricuspid lateral tooth in contrast to the broad trapezoidal pentacuspoid lateral of the Pomatiasidae; (3) the outer marginal tooth has nearly uniform-sized, narrow, sickle-shaped cusps, in contrast to the Pomatiasidae which have several enlarged cusps over the end of the shaft mesad to the smaller filiform cusps; and (4) the central tooth is relatively long and slender and has usually only a narrow beak-like mesocone in contrast to the broad short centrals of the Pomatiasidae, which have a large mesocone flanked on each side by a nearly equal-sized ectocone and a much smaller more posteriorly located ectocone.

CISTULOPSINAE. The radula of the two genera in this subfamily are similar to other Annulariidae in that the transverse rows of teeth strongly overlap, the central and lateral teeth are relatively long and narrow with a long beak-like central cusp, and the outer marginal teeth lack enlarged cusps at the apex of the shaft.

Cistulops r. raveni (Crosse). Five radula were extracted from dried specimens (USNM 393084; Tafelberg, Curacao). The central and lateral teeth are tricuspid (fig. 6, A, B). Each central tooth bears a large mesocone and a much smaller ectocone on each side. Similarly the lateral tooth is tricuspid with a large mesocone and a minute ectocone and entocone.

Troschelvindex c. candeana (Orbigny). Radulae were recovered from dried specimens (USNM 535559; outside of Havana Cemetery, Havana, Cuba). In most particulars the teeth are similar to *Cistulops r. raveni*. The ectocones on the central tooth are slightly larger in proportion (fig. 6, C).

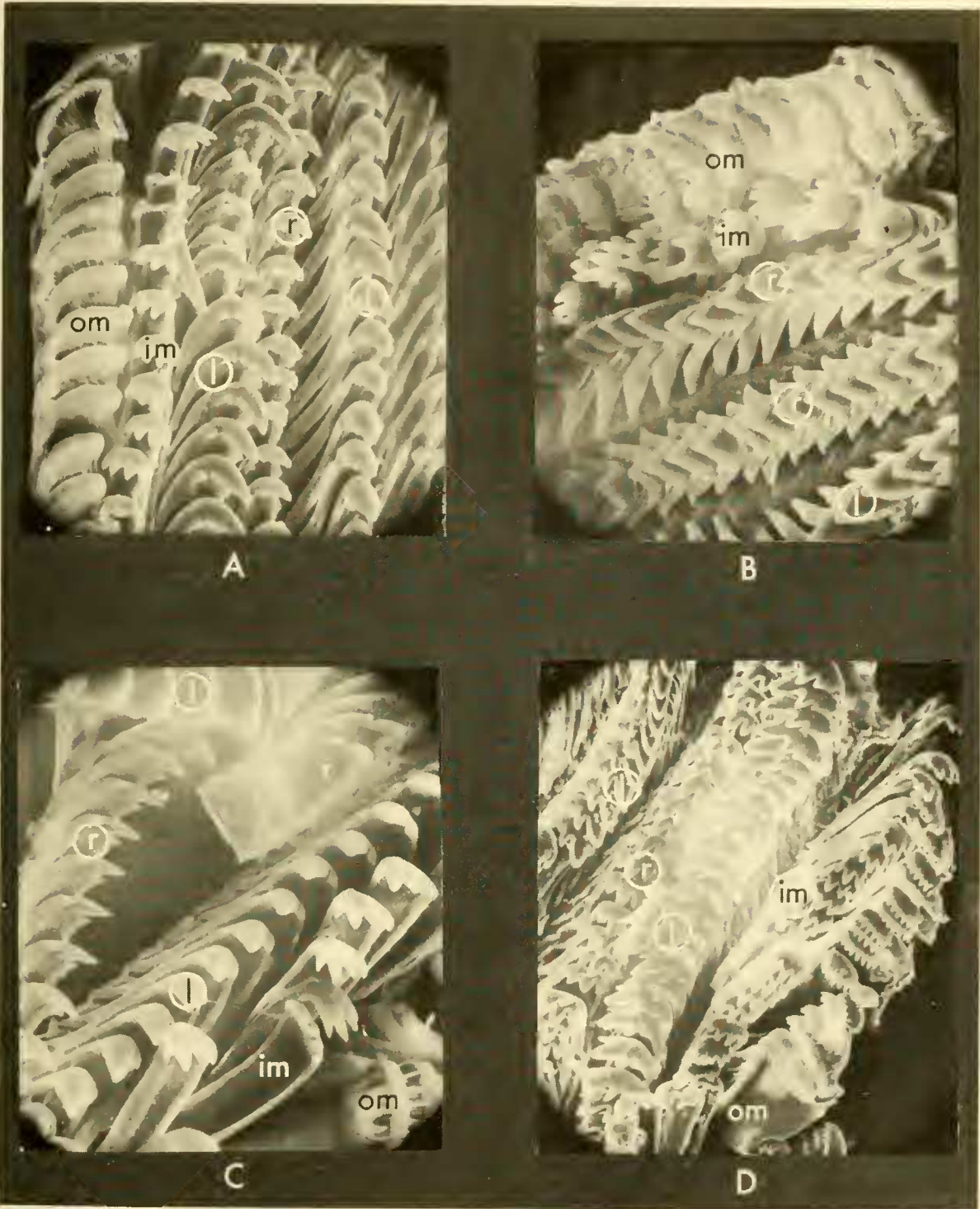


FIG. 6. SEM micrographs of radula. A. *Cistulops r. raveni* (Crosse) (USNM 293084) ($\times 476$). B. same ($\times 440$). C. *Trochelvindeix c. candeana* (Orbigny) USNM 535559 ($\times 457$). D. *Tropicophora haemastomum* (Anton) (UF 23558) ($\times 481$). Legend: r-central, l-lateral, im-inner marginal, om-outer marginal.

The long slender cusps on the central and lateral teeth and the blade-like cusps on the outer marginal tooth of the Annulariidae contrast strongly with the shorter blunter cusps on the teeth of the Pomatiasidae. In addition the broadly overlapping transverse rows of teeth in the annulariids, which reinforce succeeding rows during feeding, are very unlike the more separated condition that exists in *Pomatias*. These differences indicate different feeding strategies. The teeth of the annulariids appear to be modified for cutting and gouging deeply into plant tissues, whereas the teeth of the pomatiasids appear to be modified for a scraping action. Correlated with these interpretations is the nature of wear on the cusps. Those in the annulariids that I examined show very little wear on the anterior teeth of the ribbon. Corresponding teeth in *Pomatias* are conspicuously worn and blunted.

The differences in annulariid and pomatiasid radular structure do not in themselves constitute characteristics sufficient for separating the two groups as distinct families. Divergent feeding strategies in land snail families as reflected by radular tooth structure is a common phenomenon (Solem, 1972, 1974). The observed differences between the annulariids and the pomatiasids may represent divergence within a single phyletic group below the family level. However, the radulae of the two groups are dissimilar to the extent that it is difficult to argue a close relationship (intra-familial) on the basis of these organs.

FEMALE REPRODUCTIVE SYSTEM

Scant information is available on the soft anatomy of pomatiasids or annulariids. Creek (1951: 608-609) described the morphology and embryology of the male and female reproductive systems of *Pomatias elegans* (Müller). The reproductive systems of no annulariid have been described prior to the account given above for *Meganipha rhecta*.

Meganipha and *Pomatias* are very similar in general plan. The most striking similarity among the two genera is the elongate cleft along the ventro-lateral margin of the capsule gland forming the terminal opening of the female system. In

Pomatias this is a modification for ovulation of a very large mucus-coated egg. By inference *Meganipha* ovulates a similar and comparably large egg.

Meganipha differs from *Pomatias* in the structure of the copulatory bursa and the adjacent segment of the oviduct. In *Pomatias* the oviduct enters the distal end of the bursa and continues to the pallial oviduct in an open groove in the floor of the bursal lumen. In *Meganipha* the oviduct and copulatory bursa are interconnected only by a narrow perforation at the end of the bursal lumen, and the oviduct continues anteriorly to the pallial oviduct as a closed tube.

MALE REPRODUCTIVE SYSTEM

Meganipha and *Pomatias* differ in three major aspects. In *Meganipha* the prostate is elongate and lies completely anterior to the transverse wall of the mantle cavity, the vas deferens is very short because of the anterior location of the prostate, and the penis is pallial in origin. In *Pomatias* the prostate is ovate in shape and only partially overlaps the mantle cavity so that its posterior half lies well within the visceral cavity, the vas deferens is considerably more elongate because of the posterior position of the prostate, and the penis is pedal in origin.

NERVOUS SYSTEM

Information relating to the brain of *Pomatias elegans* (Müller) is taken from Fretter and Graham (1962: 310). The only annulariid to be described is *Meganipha rhecta* (see above). Three major features distinguish the nervous system of *Meganipha* from *Pomatias*: (1) The brain of *Meganipha* is an advanced epiathroid condition. The pleural ganglia are dorsal-lateral in position and are partially fused with the corresponding cerebral ganglia. The brain of *Pomatias* is not an advanced epiathroid condition. The pleural ganglia are lateral in position and each is attached to the corresponding cerebral ganglion by a slender connective that is about as long as the pleural ganglia. (2) *Meganipha* is zygoneurous between the supraoesophageal and the left pleural ganglia. In *Pomatias* zygoneury does not occur

between the supraoesophageal and the left pleural ganglia. (3) The penis of *Meganipha* is innervated by the left pleural ganglion via the suboesophageal nerve. The penis of *Pomatias* is innervated by the right pedal ganglion.

SUMMARY

The data currently available support the separation of the Annulariidae and Pomatiasidae as distinct families. Data relating to the soft anatomy of these two families are very limited, except for the radula. Sufficient numbers of radulae have been examined to characterize the Annulariidae and the Pomatiasidae as distinct and natural categories. The Cistulopsinae is herein considered to be primitive in characteristics of its radula and is a subfamily of the Annulariidae. Other data available on the reproductive systems and nervous system also support the separation of the Annulariidae from the Pomatiasidae. However, far more anatomical information is needed before definitive arguments can be made relating to this question.

The two families are characterized as follows:

POMATIASIDAE

1. Central tooth of radula with 5 cusps—a large mesocone, a subequal ectocone on each side, and a smaller ectocone posteriorly on each side (fig. 5, B, C).
2. Lateral tooth broad, with a large mesocone, a smaller entocone and two subequal ectocones (fig. 5, D).
3. Cusps on outer marginal tooth dimorphic, with 3-6 enlarged cusps over end of shaft, contrasting strongly with more slender filiform cusps that form a comb laterally (fig. 5, E, F).
4. Oviduct entering copulatory bursa and continuing to albumen gland as a groove within the bursal lumen.
5. Prostate compact and partially overlaps the mantle cavity and the visceral coelom.
6. Penis pedal in origin, innervated by the right pedal ganglion.
7. Pleural ganglia lateral in position and attached to corresponding cerebral ganglia by a slender connective.

8. Supraoesophageal ganglion not connected to the left pleural ganglion thru zygoneury.

ANNULARIIDAE

1. Central tooth of radula with a single long mesocone (fig. 2, D). A small rudimentary ectocone also may be present on each side (Cistulopsinae, fig. 6, A, B, C).
2. Lateral tooth similar to central tooth; with a single elongate cusp (fig. 2, D, E), or with an elongate mesocone bordered by a rudimentary ectocone and entocone (Cistulopsinae, fig. 6, A, B, C).
3. Cusps on outer marginal tooth monomorphic, forming a uniform comb along entire length of rasping margin (fig. 2, B, C).
4. Copulatory bursa connected to oviduct through a small terminal perforation. Oviduct continuing to albumen gland independently along side of bursa.
5. Prostate elongate and lying completely anterior to transverse wall of mantle cavity.
6. Penis pallial in origin, innervated by the left pleural ganglion.
7. Pleural ganglia dorsal-lateral in position and partially fused to the corresponding cerebral ganglia.
8. Supraoesophageal ganglion and left pleural ganglion connected by zygoneury.

LITERATURE CITED

- Baker, H. B. 1924a. New land operculates from the Dutch Leeward Islands. *The Nautilus*. **37**:1-6.
- Baker, H. B. 1924b. Land and freshwater mollusks of the Dutch Leeward Islands. *Occ. Pap. Mus. Zool. Univ. Mich.* **152**:1-159.
- Baker, H. B. 1928. Mexican mollusks collected for Dr. Bryant Walker in 1926. *I. Occ. Pap. Mus. Zool. Univ. Mich.* **(193)**:1-65.
- Bartsch, P. 1946. The operculate land mollusks of the Family Annulariidae of the Island of Hispaniola and the Bahama Archipelago. *Bull. U.S. Nat. Mus.* **192**:1-264, pls. 1-38.
- Creek, G. A. 1951. The reproductive system and embryology of the snail *Pomatias elegans* (Müller). *Proc. Zool. Soc. Lond.* **121**:599-640.
- Dall, Wm. H. 1905. An arrangement of the American Cyclostomatidae with a revision of the nomenclature. *Proc. Malac. Soc. Lond.* **1**:208-210.
- Fretter, V. and A. Graham. 1962. *British Prosobranch Molluscs*. i-xvi, 1-755. Ray Society, London.

- Golikov, A. N. and Y. I. Starobogotov. 1975. Systematics of prosobranch gastropods. *Malacologia* 15:185-232.
- Henderson, J. B. and P. Bartsch. 1920. A classification of the American operculate land mollusks of the Family Annulariidae. *Proc. U.S. Nat. Mus.* 58:49-82.
- Pfeiffer, L. 1858. *Monographia Pneumonopomorum Viventium*. Suppl. 1:1-viii, 1-284. Cassellis.
- Solem, A. 1960. Notes on South American non-marine Mollusca. *Estr. Ann. Mus. Civico Storia Nat. Genova* 71:416-432.
- Solem, A. 1961. A preliminary review of the pomatiasid land snails of Central America (Mollusca, Prosobranchia). *Arch. Moll* 90:191-213.
- Solem, A. 1972. Malacological application of the Scanning Electron Microscope. - Radular Structure and Functioning. *Veliger*. 14:327-337.
- Solem, A. 1974. Patterns of radular tooth structure in carnivorous land snails. *Veliger*. 17:81-88.
- Thompson, F. G. 1967. A new pomatiasid from Chiapas, Mexico. *The Nautilus*. 80:24-28.
- Torre, C. and P. Bartsch. 1938. The Cuban operculate land shells of the subfamily Chondropominae. *Proc. U.S. Nat. Mus.* 85:193-423; pls. 7-9.
- Torree, C. and P. Bartsch. 1941. The Cuban operculate land mollusks of the family Annulariidae, exclusive of the subfamily Chondropominae. *Proc. U.S. Nat. Mus.* 89:131-385; pls. 9-57.
- Venmans, L. A. W. E. 1959. Notes on land and freshwater Mollusca of southern France. *Basteria* 23:77-88.
- Wenz, W. 1938-1944. *Handbuch der Paläozoologie*, Bd. 6. Gastropoda: Prosobranchia. 1-1639. Berlin.

TAREBIA (PROSOBRANCHIA: THIARIDAE)
IN CUBA

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In *Nautilus* 89(4): 106 (October 1975) I noted the presumably first report of the presence of the Asian thiarid *Tarebia granifera* (Lamarck, 1816) in Oriente Province, Cuba. I did not then know of a previous mimeographed item by Miguel L. Jaume of July 15, 1972 (Circulares Museo y Biblioteca de Zoología de La Habana pp. 1523-1525) in which the presence of this species in extraordinary numbers was reported in the Río Cerrajón, 14 km from

Cupeyal, Yateras, Oriente (20°27'48"N, 75°03'4"W). This locality, as well as the others mentioned in my report (loc. cit.) are located generally in the SE tip of Oriente Province, where *Tarebia* seems to be confined at present. This would seem to suggest that the invasion proceeded from Hispaniola which lies only 75 km to the east of Cabo Maisí. *Tarebia* was reported from there by Murry in 1971 (*The Biologist*, 53(3).

ASIAN CLAM, *CORBICULA*, THREATENS
HAWAII

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I found living *Corbicula manilensis* Philippi 1841 being sold as food in Kailua, Oahu Island, Hawaii, on August 18, 1977, in the "Open Market" run by the City and County of Honolulu for the small local

farmer and importer. Upon checking with the Department of Agriculture Plant Quarantine Office, it was determined that these clams had entered the state illegally.